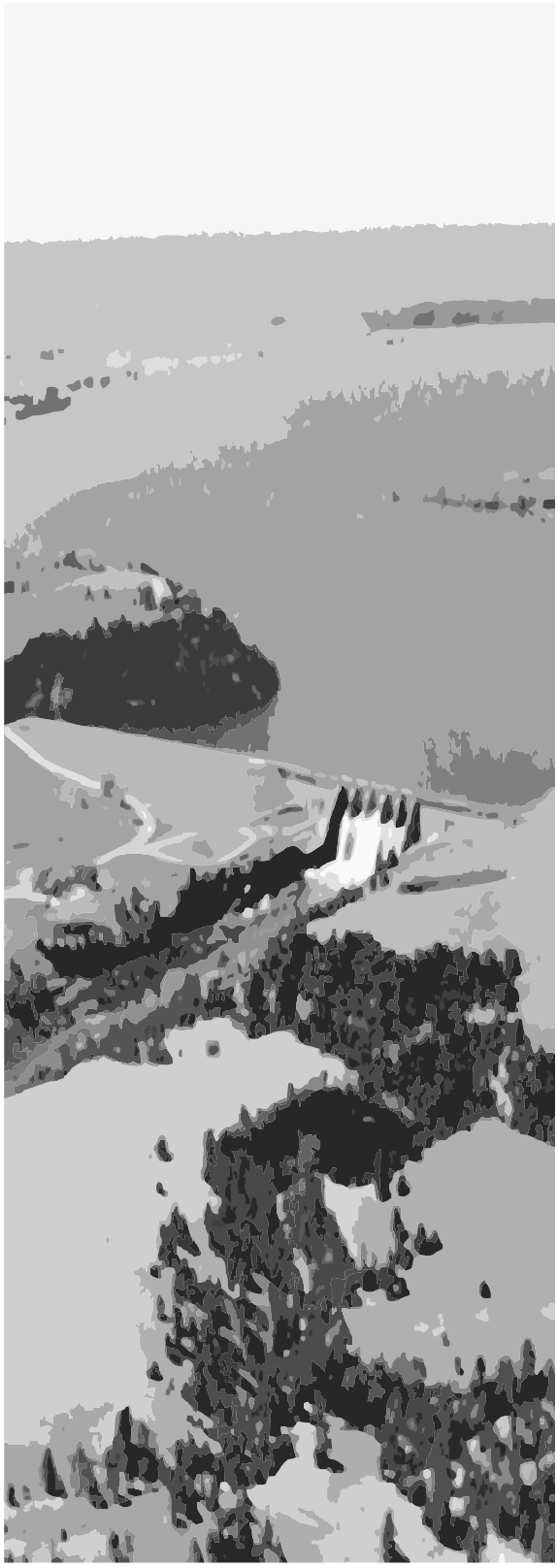

CHAPTER TWO
Alternatives

With help from the Angostura Irrigation District, Tribes, and other cooperating agencies, Reclamation developed a range of alternative plans to renegotiate a new water service contract with the District and manage water resources at Angostura Reservoir. Reclamation typically develops alternatives that renew water service contracts since the Reclamation Project Act of 1939 requires it. Policy and CEQ (Council of Environmental Quality) regulations for NEPA (the National Environmental Policy Act), however, require a full array of alternatives, including reasonable alternatives outside the authority of Reclamation to implement.

Chapter Two describes the four alternatives in this EIS (environmental impact statement).

- The *No Action Alternative* would mean no change in the water service contract beyond those required by law and no change in management of water at the reservoir.

- The *Reestablishment of Natural Flows Below the Dam Alternative* would, as the title implies, reestablish natural flows as much as possible in the Cheyenne River downstream of the dam.

- The *Improved Efficiencies Alternative* (the Preferred Alternative) would institute measures to save irrigation water, including a public process to determine how to use the saved water.

- The *Reservoir Recreation and Fisheries Alternative* would give priority to recreational use and fisheries at the reservoir.

Two other alternatives—analyzed but eliminated during the course of the study—can be found in the "Alternatives Considered But Eliminated from Detailed Study " section of this chapter. The Pine Ridge Reservation Irrigation Alternative would have irrigated lands at the town of Red Shirt, in addition to the District, while the Hydropower Alternative investigated power generation for benefit of the Cheyenne River Sioux Tribe.

Environmental impacts of the alternatives are detailed in Chapter Four and summarized in Table S.1 in the Summary. Analyses were conducted for a 25-year contract period.

NO ACTION ALTERNATIVE

In the No Action Alternative, Reclamation would renew the existing water service contract with the District, making only minor modifications to assure that the new contract conformed with Reclamation law and the agency's contract policy.

This definition may surprise those expecting that No Action would mean that Reclamation take no action whatsoever, allowing the temporary contract with the District to lapse. Under CEQ regulations for implementing NEPA, however, No Action may be defined as *no change from current management*. This interpretation was recommended by CEQ for use in a similar Reclamation contract renegotiation case in the Central Valley Project of California *(Federal Register*, Vol. 54, No.128, Thurs. July 6, 1989, pp. 28477-78). Reclamation has adopted the interpretation for use in this EIS.

Water available in the reservoir was predicted by AGRAOP, a river operations computer model developed for this EIS. AGRAOP used inflows into Angostura (including an evaporation allowance) for 1953-1997 to project water available for 45 years into the future (until 2042). The 1953-1997 period was chosen because it was considered representative for the Angostura area, included a drought period, and because it was available.

The model projected active conservation in the reservoir, ranging from the minimum elevation of 3163 feet (top of the inactive pool and the level of the District's canal inlet) to the top of the conservation pool at elevation 3187.2 feet. At the latter elevation, reservoir storage would be 112,600 AF (acre-feet) according to a December 1997 area capacity table. Storage would be reduced to 68,300 AF by 2042 according to a 2042 area-capacity table because of sedimentation. Annual discharge from the reservoir to the Cheyenne River averaged 59.9 cfs (cubic-feet/second) from 1953-1997.

Figure 2.1 shows irrigation facilities and lands in the District.

Irrigation

Up to 12,218 acres in the District would be irrigated in the No Action Alternative. Application of water would continue at the 2½ AF/acre rate. Based on AGRAOP predictions, the District would be able to irrigate 12,218 acres for all but 3 years from the present until 2042, or 93% of the time. Average CIR (crop irrigation requirement) would be 41,800 AF. Water shortages in the 3 short years would range from 11,000-32,000 AF. The District would also be able to irrigate 10,000 acres (their average irrigated acreage) for all but 3 years from the present until 2042, 93% of the time. Average CIR would be 34,200 AF for the smaller acreage. Water shortages in the 3 short years would range from 3,000-6,000 AF.

Fig. 2.1

ANGOSTURA UNIT

LEGEND

- RESERVOIR BOUNDARY
- CANAL/DITCH
- PRIMARY ROUTE
- ROAD
- RAILROAD
- CAMPING SITE
- CONCESSIONS
- PARK HEADQUARTERS
- PICNICKING SITE
- BOAT RAMP
- IRRIGATION DISTRICT

WIND CAVE NATIONAL PARK

BLACK HILLS NATIONAL FOREST

BUFFALO GAP NATIONAL GRASSLAND

To Rapid City

79

87

385

18

71

Buffalo Gap

Oral

Smithwick

HOT SPRINGS

Cold Brook Reservoir

CUSTER COUNTY

FALL RIVER COUNTY

CHEYENNE RIVER

Fall River

Cottonwood Creek

Lame Johnny Creek

Beaver Creek

Elm Creek

Spring Creek

Iron Dyke Draw

W.B. Draw

Hay Canyon

ANGOSTURA CANAL

Plum Creek

Sand Creek

Slate Springs Creek

Horse Camp Draw

Sheps Canyon

Cascade Creek

Teepee Creek

Dry Creek

Horsethief Creek

ANGOSTURA DAM

ANGOSTURA RESERVOIR

SOUTH DAKOTA

BOR Field Office Rapid City

BOR Field Office Pierre

Hot Springs

Angostura Reservoir Area

LOCATION MAP

Dakotas Area Office GIS

U.S. DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION

N W E S

0 1 2 3

MILES

Date: 14-SEP-2000
e:/data/angostura/resarea/mapangels

Recreation, Fisheries, and Downstream Flows

Recreation and fisheries in the reservoir and flows in the river downstream of the dam would depend on inflows into the reservoir, but in any case would be secondary to District irrigation. Reservoir levels would range from elevation 3163 feet to elevation 3187.2 feet, with target elevations from December-October of 3187.2 feet, and in November of elevation 3184 feet. According to the model, annual discharge to the river would range from 60.2-68.4 cfs, depending on whether 12,218 acres (the maximum) or 10,000 acres (the average) were irrigated.

Legislation

Since Angostura Reservoir would remain allocated to irrigation and flood control in this alternative, no new legislation would be required.

REESTABLISHMENT OF NATURAL FLOWS BELOW THE DAM ALTERNATIVE

This alternative would reestablish—as nearly as possible—natural flows in the Cheyenne River downstream of the dam by setting new operating criteria for the reservoir. (Stock dams upstream of the reservoir, groundwater pumping, and changes in farming practices make complete reestablishment of natural flows impossible).

Radial gates at the dam would be completely opened, with inflows allowed to pass through the reservoir. Storage would fall and maximum water elevation in the reservoir would be the spillway crest at elevation 3157.2 feet. Surface area would be reduced, which would drop even more in the future as sediment filled the reservoir.

Irrigation

While it is Reclamation policy to pursue renewal of expiring water contracts, no contract would be signed with the District in this alternative. Thus, no water would be available from the Angostura Unit for irrigation. For purposes of analysis, it was assumed that the only irrigation in the area would be private irrigation below the dam along the river.

Recreation, Fisheries, and Downstream Flows

Average annual inflows into the reservoir would be 89,500 AF (123.5 cfs) in this alternative based on adjusted inflows for 1953-1997, while storage would fall to 22,500 AF, and to 2,400 AF by 2042. Surface area would drop to 1,661 acres at elevation 3157.2 feet (top of inactive storage). By about 2021, the reservoir would completely fill with sediment (22,500 AF/985 AF of sediment per year = 23 years from 1998 = 2021), with only a limited water surface area except during peak flows. Once the reservoir filled, sediment would pass downstream. Annual discharge to the river would average 120.7 cfs, with periodic flooding (up to 25,000 cfs average daily flow), scouring the river channel and re-establishing natural plant succession within the riparian zone. Low flows in the river below the dam would be more frequent, and the river could occasionally dry up in summer.

Legislation

Changing priority allocations in the reservoir from irrigation and flood control to natural flows would require change in the Flood Control Act of 1944, which governs the Pick-Sloan Missouri River Basin Program.

Changes in State law might also be needed to preserve instream flows below the dam from diversion.

IMPROVED EFFICIENCIES ALTERNATIVE (PREFERRED ALTERNATIVE)

The Improved Efficiencies Alternative is Reclamation's Preferred Alternative since it would best meet the purpose of and need for action in this EIS.

This alternative would increase both efficiency of the District's water delivery system and on-farm efficiencies. It would include measures like lining canals and laterals, putting laterals into pipe, improving water measuring devices, leveling fields, irrigating by gated pipe or sprinkler, installing automated turnouts, providing education on irrigation, and instituting BMPs (Best Management Practices). Specific locations for these measures have not been determined.

The water saved could be used for recreation, fisheries, downstream flows, or other uses. Reclamation would establish a public process to determine how best to use the saved water. Reservoir operations would be planned from a hydrology model, with economic and environmental data used to refine it. Environmental effects would be compared to predictions, with input to the model modified accordingly.

This alternative would save an estimated 1,870-3,200 AF of water by improving delivery system efficiency, another 4,320-6,160 AF by increasing on-farm efficiencies. Water savings assume an average net irrigation consumptive use of 18.74 inches. They were estimated on an increase of distribution system efficiency of 5% (from 76% to 81%) and an increase of on-farm efficiency of 10% (from 60% to 70%). It should be noted that the nearby Belle Fourche Project improved system efficiency by 10% recently, although this system was not as efficient as the Angostura system to begin with. On-farm efficiency could easily increase by implementing a combination of sprinkler irrigation, surge valves, gated pipe, and an education program.

Table 2.1 estimates costs, water saved, and costs per AF of water saved for various delivery system efficiency improvements. Table 2.2 does the same thing for on-farm improvements. Total estimated cost to save 6,000-9,000 AF of water would range from $3,250,000-$4,660,000. Delivery system improvements typically involve

Table 2.1: Costs/Water Savings of Delivery System Improvements[1]

Delivery System Efficiency Improvements	Flow Range (cfs)	Cost Range (Feet)	Units (Feet)	Costs ($1,000)	Water Saved (AF)	Cost/AF
Lining Main Canals	60-300	$50-$70	21,120	$1,060-$1,480	760-1,980	$530-$1,960
Lining Laterals	20-35	$10-$16	25,533	$260-410	230-340	$750-$1,810
Converting Laterals to Pipe	6-20	$28-$42	41,687	$1,170-$1750	880	$1,330-$1,990
TOTAL WATER SAVED					1,870 -3,200	

[1] Calculations and assumptions can be found in Appendix V.

capital through either rehabilitation (improving the system to original efficiency) or modernization (improving the system to current achievable efficiency). On-farm efficiency improvements are generally the most economical in regard to cost/AF of water saved.

Improvements in addition to those presented in the tables are also described. While they could directly improve water management capabilities and efficiencies of the system, they were not included in the tables because of the difficulty of quantifying their costs/AF of water saved. Other delivery system efficiency improvements that could be considered include automated turnouts, automated canal controls, improved water measurement devices, and a re-regulation reservoir.

On-farm options such as irrigation scheduling and BMPs are basic irrigation practices requiring minimal capital investment, which—when coupled with an education program—could result in a significant volume of water saved. Interest in automated irrigation (such as surge valves and sprinklers) could be increased by educating irrigators on the efficiency and relatively low cost. By adding more surge valves, implementing irrigation scheduling methods, and employing other educational efforts, the goal of saving 6,000 AF by increasing on-farm efficiencies could be realized.

Other on-farm efficiency improvements that could be considered include field leveling, further education, and irrigation scheduling.

Table 2.2: Costs/Water Savings from On-farm Efficiency Improvements[1]

On-Farm Efficiency Improvements	Cost Range	Units Identified[1]	Costs ($1,000)	Water Saved (AF)	Cost/AF
Implementing Surge Valves	$2,000-$2500 each	9 valves	[2]$18-$23	180-720	$30-$130
Converting to Center Pivots	$30,000-$40,000 each	19 pivots	$570-$760	950-1,500	$380-$800
Implementing Gated Pipe without Surge Valves	$2.50-$3.35/ft	70,000 ft	$175-$235	190-940	$190-$1,250
BMPs/Education Program				3,000	
TOTAL WATER SAVED				4,320-6,160	

[1] Calculations and assumptions used are found in Appendix V.
[2] Units determined by input from the District and/or from District data.

Irrigation

A contract would be signed with the District for irrigation ranging from 12,218 to 10,000 acres. According to the AGRAOP model, irrigating 12,218 acres would be possible while drawing the reservoir down to elevation 3163 feet for all but 3 years until 2042, or 93% of the period. Water shortages would range from 2,000-5,000 AF. Irrigating 12,218 acres to elevation 3170 feet would be possible all but 3 years, or 93% of the period. Shortages would range from

3,000-25,000 AF. Irrigating 12, 218 acres to elevation 3175 feet would be possible all but 7 years, or 84% of the period. Shortages would range from 2,000-28,000 AF. Irrigating 12,218 acres while maintaining elevation 3184 would be possible only 1 year, or 2% of the period. Shortages would range from 1,000-31,000 AF. Irrigating 10,000 acres drawing the reservoir to elevation 3163 feet would be possible for all years until 2042. No shortages would occur. Irrigating 10,000 acres to 3170 feet would be possible for all but 2 years, or 96% of the period. Shortages would range from 1,000-3,000 AF. Irrigating 10,000 acres to elevation 3175 feet would be possible all but 2 years, or 96% of the period. Shortages would range from 12,000-17,000. Irrigating 10,000 acres to elevation 3184 would be possible for only 1 year, or 4% of the period. Shortages would range from 700-24,000 AF.

Recreation, Fisheries, and Downstream Flows

Recreation, fisheries, and downstream flows would depend on how saved water were used. Storage at elevation 3187.2 feet would be reduced to 68,300 AF by 2042, based on the estimated 1997 area-capacity table. Elevations of the reservoir would range from a minimum of 3163 feet to a maximum of 3187.2 feet. Surface area would be 2,100 acres at elevation 3163 feet; 2,780 acres at 3170 feet; 3,200 acres at 3175 feet; and 4,300 acres at 3184 feet based on the estimated 1997 area capacity table. This would drop in 2042 to 1,080 acres at elevation 3163 feet; 1,760 acres at 3170 feet; 2,400 acres at 3175 feet; and 3,900 acres at 3184 feet. These figures are based on the estimated 2042 area capacity.

The alternative would set target elevations of 3187.2 feet December-May; elevation 3186 feet in June; elevation 3185 feet in July; and elevation 3184 feet for August-November. This would provide for irrigation, as well as improving recreation and fish habitat.

Annual discharge to the river from the present until 2042 would average 68.9 cfs while irrigating 12,218 acres to reservoir elevation 3163 feet. Irrigating 12,218 acres to 3170 feet would provide an annual discharge averaging 70.6 cfs; to 3175 feet 71.5 cfs; and to 3184 feet 86.1 cfs. Irrigating 10,000 acres to elevation 3163 feet would provide until 2042 annual discharge averaging 76.3 cfs; to 3170 feet 77.3 cfs; to 3175 feet 78 cfs; and to 3184 feet 88.8 cfs.

Legislation

Changing priority allocations in the reservoir would require legislation to change the Flood Control Act of 1944. Special legislation might also be required if Reclamation were to adopt changes in authorized uses of the Angostura Unit.

Changes in State law might also be needed to protect instream flows below the dam from diversion.

RESERVOIR RECREATION AND FISHERIES ALTERNATIVE

Recreation and fisheries in the reservoir would receive priority in this alternative, which would eliminate—except in years of extreme drought—low reservoir levels and consequent effects on recreation and fish.

Irrigation

A contract would be signed with the District for irrigation ranging from 12,218 acres to no irrigation at all. In any case, irrigation would be secondary to reservoir recreation and fisheries in this alternative. According to the model,

irrigation of 12,218 acres would be possible while drawing the reservoir to elevation 3170 feet for all but 8 years until 2042, or 82% of the period. Water shortages would range from 3,000-37,000 AF. Irrigating 10,000 acres to elevation 3170 feet would be possible for all but 3 years until 2042, or 93% of the period. Shortages would range from 4,000-27,000 AF.

Reclamation would reallocate O&M (operations and maintenance) and construction costs to include recreation, fish, and wildlife benefits and would reduce the District's share of O&M costs proportionately. This would increase Reclamation's proportion of the costs covered by Federal funding.

Recreation, Fisheries, and Downstream Flows

Boating and fishing are common pursuits at Angostura Reservoir, so recreation was tied directly to elevations at which boat ramps were usable. Elevation 3170 feet was established as the minimum reservoir elevation in this alternative (Table 2.3). Elevation 3170 feet would allow use of two boat ramps, with four ramps available at elevation 3172 feet, and all eight available at elevation 3175 feet.

This alternative would set a target elevation of 3187.2 feet December-May; 3186 feet in June; 3185 feet in July; and 3184 feet August-December (Table 2.3). These targets would establish beaches, help fish propagation, and would maintain a larger reservoir water surface area. Elevations would range from a minimum of 3170 feet to a maximum of 3187.2 feet. Surface area at elevation 3170 feet would drop from about 2,680 acres (estimated from the 1997 area-capacity table) to about 1,760 acres (estimated from 2042 area-capacity). Water conservation measures would be taken to minimize drawdown when the reservoir elevation dropped below 3173.0 feet.

Table 2.3: Water Use in the Reservoir Recreation and Fisheries Alternative

Elevation (Feet)	Recreational Benefit
3187.2	Target elevation December-May—most favorable for fish
3186	Target elevation in June—most favorable for fish and for beach formation
3185	Target elevation in July—most favorable for fish and for beach formation
3184	Target elevation in August-November—most favorable for fish and for beach formation
3175	All eight boat ramps at reservoir usable for April - September
3173	Elevation at which water conservation measures would be taken in Reservoir Recreation and Fisheries Alternative to preserve recreational benefits for April - September
3172	Four boat ramps usable for April - September
3170	Two boat ramps usable for April - September
3163	Top of inactive pool—no boat ramps usable

The model showed annual discharge to the river until 2042 while irrigating 12,218 acres to elevation 3170 feet to be 62.3 cfs. Irrigating 10,000 acres to elevation 3170 feet would provide an annual discharge averaging 70 cfs.

Legislation

New legislation would be needed to re-authorize the Angostura Unit for recreation and fish and wildlife benefits. New legislation also would be needed to reallocate construction costs of the

Angostura Unit for new uses. Increases in congressional appropriations would be needed to cover greater Federal expenditures for O&M. Reallocation of O&M costs could be done under existing legislation.

ALTERNATIVES CONSIDERED BUT ELIMINATED FROM DETAILED STUDY

Two alternatives were eliminated during the course of the EIS: The Pine Ridge Reservation Irrigation Alternative and the Hydropower Alternative. These are described below, along with the reasons for eliminating them.

Pine Ridge Irrigation Alternative

This alternative would have irrigated 400 acres of a low-lying area next to the river on the Pine Ridge Reservation at Red Shirt (the acreage delineated irrigable in Corke 1994) and up to 12,218 acres in the Angostura Irrigation District. All areas would have been irrigated at the 2½-AF/acre rate. Water for recreation and fisheries, the riparian area along the river, and instream flows would have been secondary to irrigation. Legislation might have been required. This alternative was eliminated at the request of the Oglala Sioux Tribe.

Hydropower Alternative

The Hydropower Alternative would have installed a power plant at Angostura Dam or in the river below the dam to benefit the Cheyenne River Sioux Tribe. Water for irrigation, recreation, fisheries, and downstream flow would have been secondary to power generation.

Angostura Dam was designed to provide power generation and was originally constructed with a small power plant having a nameplate capacity of 1,200 kilowatts. The plant was intended to operate with water surplus to irrigation needs. Due to a very limited water supply, however, the plant operated only sporadically during its first 10 years. Finally, in 1960 during very dry conditions, operation was discontinued.

Reclamation conducted studies in 1961-1962 on the feasibility of continued operation. These studies found that many stock ponds had been constructed in the basin above the reservoir during the late 1940s and the 1950s, and that the irrigation diversion requirements were larger than originally contemplated. It was concluded that the water supply for the Angostura Unit had been depleted by at least 30% from the time of the original plans, that irrigation use was substantially higher than estimated in the original water supply study, and that the original justification for the power plant was marginal at best, with some of the findings invalidated by actual operating experience. Changes in the Cheyenne River basin reduced the water supply to the point that power could be generated in only 25 months out of the 33 years covered by the studies. It was therefore recommended that the power plant be abandoned and put up for salvage. The plant was not operated after 1960; and, during the early 1970s, it was dismantled and sold for salvage.

For the EIS, reservoir inflows for the last 20 years were reviewed and compared to inflows used in the 1962 study. Estimated average inflow before 1962 was estimated to be 108,500 AF/year, with actual inflow from 1976-1997 averaging 78,300 AF/year. It was concluded that the water supply remains inadequate for a power plant at the dam.

The other possibility would be to develop hydropower downstream next to the Cheyenne River Reservation. A low head dam would have to be built to create the head required to generate electricity, or the velocity of the river itself would need to be great enough to run a generator efficiently. Because of the low gradient of the Cheyenne River, a low head dam

would back up a lake several miles long. This would eliminate existing riparian habitat and prevent fish movement upriver. Also, the high cost of the dam would make this alternative economically infeasible.

IMPACTS SUMMARY

Table S.1 summarizes environmental impacts of the alternatives. Detailed analysis of impacts can be found in Chapter Four.

North Unit Marina, Angostura Reservoir